**Thermoelectric Carbon Monoxide Sensor Using Co-Ce Catalyst**（小三，加粗，居中，段前1行，段后0行）

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（正文，五号，行距12磅，段前段后0行，参考文献标注用上标）（英文用Times New Roman）

**Abstract**： A thermoelectric (TE) carbon monoxide sensor was obtained composed of Co-Ce catalyst layer and TE layer. The Co-Ce catalysts were prepared by co-precipitation and tabletting method. Several factors including the atomic ratio of Co/Ce, pH value, calcination temperature, and operating temperature were investigated. EDS analysis was utilized to determine the final composition between Co and Ce. Methods of BET, XRD, SEM were used to characterize the catalysts. When Co10.0Ce catalyst showed a high temperature difference output (44oC) at an operating temperature of 92°C, the TE sensor possessed well sensing property to 3 vol.% CO, with a high output voltage signal (42 mV). The response and recovery time of the TE sensor was 72 s and 68 s, respectively. Furthermore, high selectivity of the sensor was also obtained in the operating temperature from 90°C to 125°C.

***Keywords****:* Catalyst, Carbon monoxide sensor, Thermoelectric film（关键字、摘要的具体格式请仿照本文）

**1. Introduction（五号，加粗，段前段后各0.5行）**

Carbon monoxide (CO) is one of the common poisonous gases, even concentration as 1 vol.% CO can be fatal. The colorless, odorless as well as non-irritating natures of CO make it difficult to be detected, and the hazard of CO is exacerbated by its wide sources. As a result, CO sensors are indispensable in many fields, such as measuring the CO concentration of vehicle emissions, industrial waste, and the indoor atmosphere. Currently, the CO sensors based on electrochemical or semi-conductor methods have been widely used, but they still have some shortage on selectivity, long-term stability, complex configurations and high cost.

In this paper, the Co-Ce oxide was used to trigger the sensor possessing high sensitivity and selectivity to CO at low operating temperature. Following these considerations, the Co-Ce oxides over CO oxidation were studied. All the oxides were prepared by co-precipitation and tabletting method. Surface area, pore volume, crystal structure, oxidation-reduction behavior of the Co and Co-Ce oxides were characterized subsequently by BET, XRD and SEM methods. Finally, using the optimal Co-Ce oxide, CO sensing property of the TE gas sensor was discussed.

**2. Experimental**

2.1 Catalyst Preparation（五号，段前段后各0.5行）

The Co-Ce oxides were prepared by the co-precipitation method in an aqueous solution. A mixed solution of Co(NO3)2·6H2O and Ce(NO3)3·6H2O was gradually added into NH4HCO3 solution drop wisely with continuous stirring. The precipitation process was carried out at 45-50°C. The slurry was aged for 9 hr, then filtered, and washed with de-ionized water several times until the pH of the filtrate kept as 7. The precipitate was dried in an oven at 100°C for 2 hr, after that, the as-dried powder was formed by tabletting method with the pressure varied from 1 MPa to 6 MPa. For all experiments, pellets with the same weight of 200 mg were utilized. Finally, all samples were calcined in air, utilizing various temperatures ranged from 250°C to 500°C.

The Co-Ce oxides were described as CoxCe1 (x as the atomic ratio of Co to Ce) in the following content. The pure Co oxides without Ce additive were also prepared by the similar procedures for comparison.

2.2 Catalyst Characterization

Energy dispersion spectroscopy (EDS, Falcon, USA) method was used to test the final composition of Co/Ce of the formed Co-Ce oxides. BET method was used to measure the surface areas of the samples by nitrogen adsorption at -196°C. The pretreatment was degasificated at 190°C for 6 hr, using a Micrometric ASAP2010 (USA) instrument in an automatic volumetric system. X-ray diffraction (XRD) spectra were obtained using a D/max2550 VB/PC X-ray diffractometer (Rigaku, Japan). Scanning electron microscope (SEM, JSM-6360LV) method was characterized by X-ray diffractometry (JEOL, Japan).

2.3 Catalytic activity and TE sensing property

Bismuth telluride was chosen as TE material for the remarkable Seebeck coefficient[1]. TE CO sensor with simple structure was fabricated by employing TE thin film (Bi-Te PN couples) and Co-Ce oxide. The structure of the sensor device is shown in Fig.1. TE layer was deposited onto a quartz glass substrate by magnetron sputtering, Co-Ce oxide centered in the TE film. The concrete size of the device was listed as following: 20 mm (length) × 20 mm (width) × 1 mm (thickness) for substrate, 8 mm × 1 mm × 350 nm for TE layer, 9 mm (diameter) × 2 mm (thickness) for the Co-Ce oxide.

The response of the TE sensor was conducted by flowing alternately 3 vol.% CO/air and N2 into the reaction chamber at a flow rate of 100 ml/min. The measurement was conducted at a constant temperature, which was provided by a silica glass tube heated by a thermal stabilized electric furnace. The catalytic activity was evaluated by the temperature difference (*ΔT*) which built between one side of the TE covered by catalyst and the other side without catalyst. The TE films, working as a feedback part, convert *ΔT* into a voltage as an output signal. All



Fig.1 Sketch (left) and picture (right) of the core structure of TE CO sensor.

（五号，居中，图表要放在每页的最上或最下）

data were monitored by a K-type thermocouple, automatically collected and analyzed by Agilent 34970A data acquisition/switch unit and Labview (NI Crop.USA).

**4. Conclusion**

The catalytic activities of Co-Ce oxides were discussed over TE CO sensor. Several parameters of the preparation Co-Ce oxides were investigated, and optimal values were found out as pH value in the co-precipitation process of 7.1, tabletting pressure as 1 MPa, calcination temperature as 400°C. Optimal catalytic activity of the Co10.0Ce was obtained at the operating temperature of 92°C. The performance of the TE CO gas sensor with the optimal Co10.0Ce was studied. The TE sensor exhibited an output voltage signal of 42 mV, the response and recovery time of the sensor were about 72 s and 68 s, respectively. Furthermore, prominent selectivity to CO and no response to H2 and CH4 in this TE CO sensor were achieved.

**References**

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